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Document Title **LAT Calorimeter CsI Crystal Quality Assurance Provisions**		

Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Calorimeter CsI Crystal Quality Assurance Provisions

DOCUMENT APPROVAL

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes	DCN #
1		Initial Release	

Table of Contents

1 PURPOSE

This specification establishes the quality and reliability assurance requirements of the Thalium-doped Cesium Iodide, CsI (Tl), scintillating crystals for the Calorimeter subsystem of the GLAST Large Area Telescope (LAT). The provisions specified herein will serve as the basis for the procurement screening, testing, handling, storage and shipping of the Calorimeter CsI (Tl). The intent of this specification is to allow the manufacturer the flexibility to implement the best proven and established practices to the maximum extent possible while still providing product, which meets or exceeds the Mission Assurance Requirements. Quality assurance requirements outlined herein are for CsI (Tl) built on a manufacturing line, which is controlled through a manufacturer's existing Quality Management (QM) program and reviewed and approved by the Swedish Procuring Agency (Buyer). The manufacturer may present alternate methods of addressing the requirements contained in this document. This specification requires the Swedish procurement agency to establish a process flow baseline.

2 SCOPE

These specifications apply to the CsI (Tl) scintillation crystals for the Calorimeter subsystem of the GLAST LAT. The crystals shall support two development models of the LAT calorimeter and 18 flight model calorimeter modules. Each module requires 96 CsI (Tl) crystals. After testing with the development models, a final determination of the CsI (Tl) crystal dimensions shall be made prior to the flight crystal fabrication. An option for additional crystals is also specified.

3 DEFINITIONS

3.1 Acronyms

CAL	The Calorimeter subsystem of the LAT
CsI or CsI (Tl)	Thalium-doped Cesium Iodide
FWHM	Full Width at Half Maximum
GLAST	Gamma-ray Large Area Space Telescope
EM	Engineering Model
FM	Flight Model
GSFC	Goddard Space Flight Center, NASA
KTH	Kungl Tekniska Högskolan
LAT	Large Area Telescope
MIP	Mandatory Inspection Points
NASA	National Aeronautics and Space Administration
NRL	Naval Research Laboratory

PIN	Positive-Intrinsic-Negative, a silicon device construction technique to provide low-capacitance, high speed photodiode response
TBD	To Be Determined
TBR	To Be Resolved

3.2 Definitions

γ	Gamma Ray
μm	micrometer
mm	millimeter
cm	centimeter
eV	Electron Volt
MeV	Million Electron Volts, 10^6 eV
ph	Photons

4 APPLICABLE DOCUMENTS

Documents that are relevant to the development of the GLAST LAT Calorimeter and its requirements include the following:

LAT-DS-00095-03	"LAT Calorimeter CsI Crystal Specification", April 2001
LAT-DS-00096-01	"Calorimeter Crystal Mechanical Test Station Requirements"
LAT-DS-00097-01	"Calorimeter Crystal Optical Test Station Requirements"
LAT-SP-00010	"GLAST LAT Performance Specification", August 2000
LAT-SS-00018	"LAT CAL Subsystem Specification", January 2001
GLAST00110	"Mission Assurance Requirements (MAR) for Gamma-Ray Large Area Telescope (GLAST) Large Area Telescope (LAT)", NASA Goddard Space Flight Center, Current Draft Sept 20, 2000
NPD 8010.2B	"NASA Policy Directive, Use of Metric System of Measurement in NASA Programs"

5 QUALITY CONTROL AND INSPECTION

The buyer (Swedish Procurement Agency) shall ensure that crystal manufacturer shall plan and follow processes, which directly affect the quality of the CsI (Tl) crystals. The buyer shall monitor, control and maintain process parameters of the crystal manufacturer to ensure that the product characteristics fall within required specifications and/or tolerances. The buyer shall establish and follow documented procedures for inspection activities to verify that the product requirements are met.

5.1 Quality Assurance

The Buyer shall maintain a quality program/system at the crystal manufacturer that compiles with any recognized U.S. Quality Program/System Standard in Effect on the contract date (e.g., ISO 9001, MIL-I-45208, ANSI N45.2) or equivalent and shall meet all requirements specified in LAT-DS-00095-03, LAT Calorimeter CsI Crystal Specification.

The Buyer shall require, in writing, manufacturer subcontractors of all tiers to comply with all applicable quality program/system requirements.

The Buyer shall tender for acceptance only those supplies or services that have been inspected and tested in accordance with its quality program/system and have been found to conform to contract requirements.

5.2 Submittal(s) Required After Contract Date

Prior to the performance of any operations involving the following, but before the start of flight manufacturing (batch of 1800 crystals), the Buyer shall deliver for NRL's review and approval:

1) a concise explanation of all manufacturing processes, including drawings,
2) a production and delivery schedule,
3) an Inspection and Test Plan. The plan shall specify, as a minimum: (1) what is to be inspected/tested, (2) the inspections/tests to be performed, and (3) the inspection/test methods or procedures to be used.
4) all proposed changes to the Customer's design or specifications.
5) evidence of its quality program/system. Such evidence may consist of a copy of the approved QA/QC plan, and shall specify the standard(s) upon which the system is based.

5.3 Crystal Traceability and Identification

5.3.1 Purpose

Each crystal should have a serial number that clearly specifies the boule from which it was manufactured and the location in that boule. The serial number shall be unique for all crystals within this contract.

5.3.2 Implementation

The crystal identification number shall be affixed on the outside of the wrapper, in a manner that will not be erased by contact with alcohol. The information on location of a crystal in a boule shall be given by drawings showing crystal ID numbers and their locations within a boule.

5.4 Crystal Contamination Control after Final Polish

Human handling contaminants (i.e., body oils, salts, lotions) on external surfaces may diffuse through the crystal with moisture, leading to ionic instability. Therefore, ESD safe cots or gloves, which will not allow the transfer of contaminants, will be required to handle the crystals during testing and assembly. Materials and processes used in the manufacturing process shall be evaluated by the buyer to determine if they cause detrimental effects to crystals.

5.5 Moisture Control

The Buyer shall describe the following processes that affect the crystal integrity due to excessive moisture:

1) Receipt, handling, and storage of crystals.
2) Exposure limits prior to processing next assembly

5.6 Boule samples

For each boule two samples should be provided in the form of highly polished cylinders, 2.5cm diameter and with 2.5 cm height for radiation testing and tracability.

5.7 Mechanical Equipment Provided by the Buyer to the Crystal Manufacturer

5.7.1 The buyer shall provide a mechanical test bench to verify all required dimension measurements as per LAT-DS-00095-03, "LAT Calorimeter CsI Crystal Specification". The test bench shall be provided along with documentation and procedures for use and if required, training will be provided to crystal manufacturer.

5.7.2 Description

The mechanical test bench is defined in referenced GLAST document LAT-DS-00096-01, "Calorimeter Crystal Mechanical Test Station Requirements". A short summary of the test bench is given below.

The mechanical test bench measures every long side of the crystal at six points using an array of digital gauges. Values from the digital gauges are summarized in a computer and the dimensions of the crystal are calculated. The chamfer is measured at three points. The short ends are measured only as the total length of the log. The results are presented in standard format for machining industry. The results will also indicate if the log has a bend or twist. The measuring cycle takes approximately 10 minutes. Additional time will be added for handling, visual inspection and cleaning.

5.7.3 Operation and Maintenance

The buyer shall provide the test bench for the buyer's use in crystal verification and inspection. The measurements with the buyer-supplied bench represent the minimum required measurements. The buyer is free to provide measurements using his own procedures and equipment in addition to this minimum. The buyer shall promptly report any breakdown or malfunction in the test bench. Maintenance of the test bench is the buyer's responsibility.

5.8 Optical Equipment Provided by the Buyer to the Crystal Manufacturer

5.8.1 The buyer shall provide an optical test bench to verify all required performance measurements. The test bench shall be provided along with documentation and procedures for use. The buyer shall be responsible for providing the Na-22 radioactive source required using the optical test bench. The mechanical and radioactivity specifications of this radioactive source shall be provided by the buyer.

5.8.2 Description

The optical test bench is defined in referenced GLAST document LAT-DS-00097-01, "Calorimeter Crystal Optical Test Station Requirements". A short summary of the test bench is given below.

The crystal light yield and light taper are measured with photo-multiplier tubes on the two small faces of the crystal and a remote-controlled motor-driven radioactive source irradiating the crystals from a perpendicular direction. The photo-multiplier tubes are Hamamatsu R669 photomultiplier tubes and are 5 cm in diameter. The radioactive source is a 3.7×10^5 Bq (10 microCurie) Na-22

source held in a lead pig with a collimating hole. This arrangement is mounted in a light-tight box with easy access to change out crystals and reposition the photo-multiplier tubes and apply pressure against the face of the crystals. The optical coupling between the photo-multiplier tube and the crystal is a dry contact. The photo-multiplier tubes are readout by standard NIM-bin based laboratory nuclear electronics. The electronics consist of a dual high-voltage power supply, a dual shaping amplifier, 2 ADCs and a custom electronics card that generates coincidence triggers, keeps track of dead-time, and acts as the interface to a PC. The motor is controlled through a Labview program. The same computer program controls the motor, acquires the data, analyzes and archives the data. When a log is inserted in the box and the program started, the program will automatically move the source to a predetermined set of positions and log data for a predetermined amount of time. The program written in Labview is installed on a PC that acts a data acquisition system and logs all data electronically.

5.8.3 Operation and Maintenance

The buyer shall provide the test bench to the crystal manufacturer for crystal verification and inspection as per LAT-DS-00095-03. The measurements with the buyer-supplied bench represent the minimum required measurements. The may provide measurements using his own procedures and equipment in addition to using buyer supplied equipment. The buyer shall promptly report any breakdown or malfunction in the test bench at the manufacturer. Maintenance of the test bench is the buyer's responsibility.

5.9 Performance measurements

The buyer shall provide performance inspection reports for 100% of the crystals delivered on this contract. These reports shall document each required and actual performance measurement on the crystal using the buyer-provided test benches. The inspection reports shall be supplied using a mutually agreeable electronic media and format.

5.10 On-Site Source Inspections

Crystal manufacturing facilities shall be subject to inspection, surveillance, and test at specified periodic intervals and places. Mandatory Inspection Points (MIPs) and visits will be notified and negotiated prior to flight crystal manufacturing. During MIP inspections, surveillance and tests will be witnessed or performed not to unduly delay the work but to verify quality during process.

The buyer shall obtain from crystal manufacturer 100% dimensional inspection reports documenting each required and actual dimension using the buyer-provided mechanical test bench described in LAT-DS-00095-03 and in referenced document, LAT-DS-00096-01, "Calorimeter Crystal Mechanical Test Station Requirements". The inspection reports shall be supplied using a mutually agreeable electronic media and format.

5.11 Inspection and Testing

Inspections and tests shall be performed to verify compliance with specification and procedures as specified in LAT-DS-0095-03. The inspection and tests should be repeated buy the buyer on procured crystals using similar test equipment and controlled hardware. These inspections shall

include physical characteristic review, evaluation of certified test data or test operation traceable to a procedure or specification. These activities are monitored or witnessed as necessary by QA. Any malfunction or observed anomalies during inspection (receiving or in process) or tests shall be processed in accordance with the buyer's failure reporting guidelines. In case of a test failure, a problem failure report shall be generated of the crystals.

Handling procedures for articles being inspected or tested shall be followed to prevent any contamination, damage or compromise of the quality of the article.

Equipment records shall be maintained in instrument logbooks, and as-run test procedures to account for all fabrication, assembly, inspection, and test operations. The entries shall be complete, self-explanatory, and signed.

Prior to testing, QA shall:

- Verify that the applicable inspection and test documents are available;
- Ensure that requirements for selection and control of articles have been implemented and that test constraints have been resolved;
- Verify that articles undergoing test are identified;
- Verify the configuration of the articles;
- Verify that the configuration of ground support equipment (GSE) is consistent with the articles under test; and
- Verify that the test equipment is calibrated, and such calibration will be effective and sustained during the test period.

During the testing, QA shall:

- Ensure that the testing is accomplished in accordance with the test specification and procedures;
- Ensure that accurate and complete recording of data and test results are performed;
- Document rework, repair or modification occurring during the test operations; and
- Document failure anomalies, nonconformances, and participate in their disposition.

After testing, QA shall:

- Ensure the proper disposition of the articles;
- Report any additional non-conformances; or failures and participate in their disposition;
- Ensure that remedial and preventive action has been accomplished relative to failures and non-conformances; and
- Verify that test results and reports are accurate, complete, and traceable to the tested article.

5.12 Control of Non-Conformances

The crystal buyer shall operate a closed loop nonconformance control system. The system requires the documentation of each nonconformance, the accumulation of nonconformance data, and the reporting of the data. Nonconforming material shall be considered to be any material in which one or more characteristics do not conform to the requirements specified in the specification.

5.13 Failure Reporting

The buyer will report failures of all items used or intended for use in flight and GSE hardware which occur during all testing which defines qualification, life or functional acceptance. The initial failure notification will include the failure information available at the time of notification. The final failure report will include or address the characteristic of the failure. In addition, it will include the identification of the failing test item, identification of the specific part or item which caused the failure (through a nonconformance item report) Failure Review Board (FRB) direction, failure investigation action taken, failure analysis, item disposition, applicable retest requirements and results, corrective actions, and verification of failure actions/report closeout.

5.14 Definition of Failures

A failure will be defined as the occurrence of the following conditions:

- Mechanical, electromechanical, or crystal performance which is beyond the specified units of the test procedure;
- Parameter fluctuation resulting in test measurements which, though within the limits of the parameter tolerances, are considered to be erratic or unexplainable drifts occurring from initial performance conditions;
- Any failure which occurs in test or other ancillary equipment while connected to the test item which is being considered to have a damaging effect of the test item or interrupts time-based testing; and

5.15 Failure During Test

In the event of a failure during flight acceptance testing, corrective measures shall be defined, reviewed and authorized by NRL FRB. The FRB shall define and approve the repeat of all, or any such portions of the test deemed necessary by the FRB to ensure integrity of the test item.

5.16 Control of Quality Records

Quality records necessary to demonstrate conformance to requirements and effective operation of the quality system shall be maintained by the buyer for review. These records may include build history, complete test run or various design analysis and studies.

Quality data and records are stored and maintained in facilities that provide a suitable environment to minimize deterioration, or damage due to fire and to prevent loss. Quality records are readily retrievable for analysis, trending, and validation of corrective action effectiveness.

Prior to release for shipment of deliverable crystal, a records review of all open items, waivers, contract work order mods, and non-conformances shall be conducted by the QA department. This review shall be conducted prior to preship review.

5.17 Acceptance Data Package and Documentation

For each crystal, mechanical dimensions and performance measurements shall be for each point measured as specified in LAT-DS-00095-03, LAT Calorimeter CsI Crystal Specification. Documentation shall follow a data format provided by the buyer. Data shall be provided by buyer on electronic media.

The acceptance data package for each crystal built and tested will have at minimum:

- A cover sheet indicating the name, crystal part number, and serial number of the item;
- The "as-built" drawing including part revision number, as applicable;
- Mechanical and electrical control drawing of the crystal, if applicable;
- Crystal's acceptance or qualification test data;
- Test summary, including operating time.
- Copy of all non-conformances documentation, failure reports, waivers, deviations and acceptance test failure documentation applicable to the item;
- Actual mass of each crystal
- Inspection and test records showing completion and acceptance of the crystal.

5.18 Change of dimensions

Slight changes to the dimensions of the crystals should be possible after the delivery of the first 130 crystals before the start of the manufacturing of the flight batch of 1800 crystals, i.e. before 1 March 2002. These changes are maximum 4 mm in crystal length and 2 mm in width or height and 1 mm in bevel length.

5.19 Incoming Inspection by Buyer

On delivery, the buyer shall perform inspections on each crystal using similar mechanical and optical test as specified in LAT-DS-00095-03, LAT Calorimeter CsI Crystal Specification. The nonconforming crystals shall be returned for credit or refund, and the buyer is expected to promptly correct or replace the crystals. Crystal buyer shall not redeliver corrected or rejected goods without disclosing the formal rejection or requirement for corrective action in writing.

The buyer shall perform acceptance tests on delivered crystals at a rate of at least 50 crystals per week.

5.20 Radiation Hardness

The radiation hardness of all crystals in a boule shall be judged by the radiation hardness of a sample from the boule. This test will be performed by the buyer on one of the crystal samples from each boule. If the sample fails the radiation test, all crystals from that boule will be rejected.

6 HANDLING AND SHIPPING (FROM CRYSTAL MANUFACTURER TO BUYER AND THEN TO FRANCE)

The crystal supplier shall pack the crystals to prevent damage and deterioration to the quality and performance of the crystals. Packaging and handling shall be performed as TBD procedures and materials. Supplier is responsible for damage to or deterioration of any goods resulting from improper packing or packaging.

Supplier will ship the goods according to the following instructions:

1. Shipping Documentation: Must include packing sheets containing purchase contract number, line item number, description and quantity of goods shipped, part number or size, inspection reports, test data, and other documents as defined in the previous sections. A shipment containing hazardous and nonhazardous materials must have separate packing sheets for the hazardous and nonhazardous materials. The shipping documents will describe the material according to the applicable classification and/or tariff. The total number of shipping containers will be referenced on all shipping documents.

2. Shipping Container Labels: Supplier will label each shipping container with the purchase contract number and the number that each container represents of the total number being shipped (e.g., Box 1 of 2, Box 2 of 2).

Crystals should be shipped in vacuum-sealed plastic bags and in such a way that the shape of each crystal is preserved. Each shipping container shall be waterproof and shall contain a maximum of 12 crystals.

The supplier shall provide appropriate shipping containers for the transport of the finished crystals to the buyer. Each container shall hold no more than 12 crystals (details to be negotiated). The supplier shall insure that the crystals are mechanically supported with appropriate material as to preserve mechanical shape of the crystals during all phases of transport.